Data dots identify aerial photos

Electronic marking system speeds interpretation of reconnaissance and surveillance film

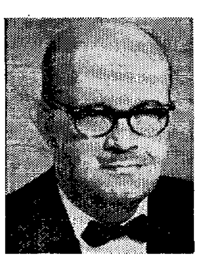
By William A. Miller
Fairchild Hiller Corp., Bay Shore, N. Y.

More rapid communication of wartime intelligence has been made possible by an electronic system that eliminates the time-consuming job of marking aerial reconnaissance photographs before they can be interpreted.

Supersonic RF-4C reconnaissance planes, streaking overhead, photograph Viet Cong convoys on the road from Hanoi to South Vietnam, military installations, troop movements and target areas. With six cameras aboard and each camera taking up to 12 pictures every second, a single plane sometimes returns from a mission with more than 4,000 pictures for every minute over the target. But before intelligence officers can study a picture, it must be identified; each frame correlated with the mission profile and marked with pertinent information. That job now is performed, simultaneously with the picture taking, by an airborne system developed by the Fairchild Hiller Corp.

The auxiliary data annotation set, ADAS, as the electronics system is called, marks the film with time, latitude, longitude, speed, barometric and radar altitude, heading, drift, pitch, roll, date, sortie number, detachment, radar mode, correlation counter, sensor or station identification, and photographing unit. The ADAS annotation system is flexible; it can be used to mark the film records of side-looking radars, infrared scanners, or any other systems that produce film records of their findings.

The author



William A. Miller, a staff consultant at the Electronic Systems division specializes in radar ranging, wide-band data link and satellite navigational systems. In addition to the design of the auxiliary data annotation set, he is also engaged in special design work on high-resolution facsimile, and optical systems.

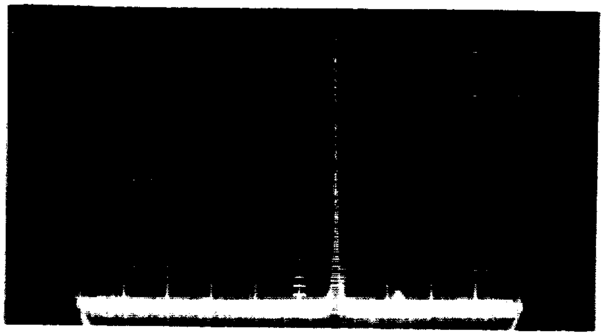
The ADAS airborne system is made up of one major assembly, the auxiliary data translator unit; several smaller subsystems and up to nine recording head assemblies that annotate the film of each sensor. A tenth recording head assembly is part of a test unit in the aircraft cockpit.

The auxiliary data translator unit contains both logic and power supply modules; it takes the mission profile data (latitude and longitude from the inertial guidance equipment, altitude from the altimeter, and so on) and translates it into a form that will drive the recording head assemblies. Some of the input to the logic modules is provided by a programed card assembly, which carries fixed data, such as date, sortie number, and so on. This assembly is inserted into the translator unit immediately before takeoff. A special timer is also used to set the translator's digital clock to the time of day.

Each recording head assembly contains a cathode-ray tube magnetically shielded and potted inside a 4½ x 1¼ inch cylindrical mount. The assembly is mounted on the film recorder of each camera, radar or infrared scanner where together with a special lens system, it projects the data display onto a previously assigned area of the reconnaissance film. Because the film sensitivity at each of the recording stations varies, the brightness of the spot of the crt must also vary; this is automatically controlled by the programed card in the translator unit.

Producing the pattern

Data is projected onto the sensor film in what is called an excess-three binary-coded-decimal data format (+3 BCD). Because this format has the advantage of high data density, less film area is required for data annotation. Two subsystems are required to produce the crt's data raster: a deflection-control subsystem, which generates vertical and horizontal sweep voltages for the crt's in the recording head assemblies; and the unblanking



Supermode laser spectrum. The spectrum is essentially that of a monochromatic signal. The scale for this photograph is the same as those for the preceding sequence of laser spectra on page 103.

mode spacing, then $\Delta\nu$ would be zero and Γ would be infinite. At that operating point, the output no longer resembles an f-m signal; instead, all the modes would oscillate in phase and have a nearly Gaussian distribution of amplitude. This output corresponds to train of very narrow pulses with a repetition rate corresponding to the frequency separation of the modes.[8]

One very interesting property of the f-m signal is that it produces no beat signal when detected on a square-law photodetector. This is easily seen if the photocurrent intensity is considered proportional to the square of the electric field. Then

$$I \propto E_0^2 \cos^2 (\omega_c t + \Gamma \cos \omega_m t)$$
$$= E_0^2 \frac{1 + \cos^2 (\omega_c t + \Gamma \cos \omega_m t)}{2} \quad (4)$$
$$= \frac{E_0^2}{2} + \frac{E_0^2 \cos^2 (\omega_c t + \Gamma \cos \omega_m t)}{2}$$

The second term represents frequencies of approximately 10^{15} cps and therefore will not be detected. This is due to the fact that the photodetector responds only to amplitude variations, whereas the f-m signal has, by definition, a constant amplitude. The photocurrent will just be an average d-c current proportional to the f-m laser intensity. This phenomenon is in sharp contrast to the case of the free-running laser, from which there are generally random components of the photocurrent at multiples of the frequency spacing between modes. (For a one-meter He-Ne laser, the photocurrent will contain frequencies at approximately 150 Mc, 300 Mc, and so on, up to about one gigacycle.)

The supermode laser

The supermode laser, diagrammed on the opposite page, is an extension of the f-m laser, which uses the controlled spectral output to produce a single frequency.[9] The output of the f-m laser is passed through a second KDP phase modulator. Since the f-m laser output can be written as

$$E = E_0 \cos (\omega_c t + \Gamma \cos \omega_m t) \quad (5)$$

then the output of the external phase modulator (which is driven at the same frequency as the modulation frequency of the f-m laser) is

$$E = E_0 \cos [\omega_c t + \Gamma \cos \omega_m t + \Gamma' \cos (\omega_m t + \Phi)] \quad (6)$$

where Γ' is the modulation index of the external modulator and Φ is the difference in phase between the two modulations. When Γ' is made equal to Γ and Φ is 180°, then (6) reduces to

$$E = E_0 \cos \omega_c t \quad (7)$$

This is a monochromatic signal at a frequency near the center of the original free-running spectrum and is shown in the figure at the left. Briefly, the supermode laser produces a single-frequency output by first controlling the free-running modes in a specific manner through the f-m laser techniques, and then converting this controlled signal to a single frequency.

Power and control

In principle, neither approach—f-m or supermode—reduces the laser's output power. For the f-m laser, the only significant losses are in the internal modulator, and these losses can be made very low. The f-m laser has produced outputs of about two milliwatts; the supermode extension has produced one milliwatt.

Both techniques control the relative amplitudes and phases of the laser modes—not the absolute frequency of the output. The central frequency of the f-m spectrum will drift as the dimensions of the optical cavity undergo thermal changes. A change in length by half a wavelength will result in a frequency shift of the whole spectrum by about 150 Mc for a one-meter laser. This is a very important problem, and several solutions are presently being studied.

Because the full power of the laser remains available, and excellent spectral control is possible, f-m and supermode lasers are potentially applicable to information-carrying, spectroscopy and holography. The experimental work was done with a gas laser, but the methods are now being applied to solid crystal lasers.

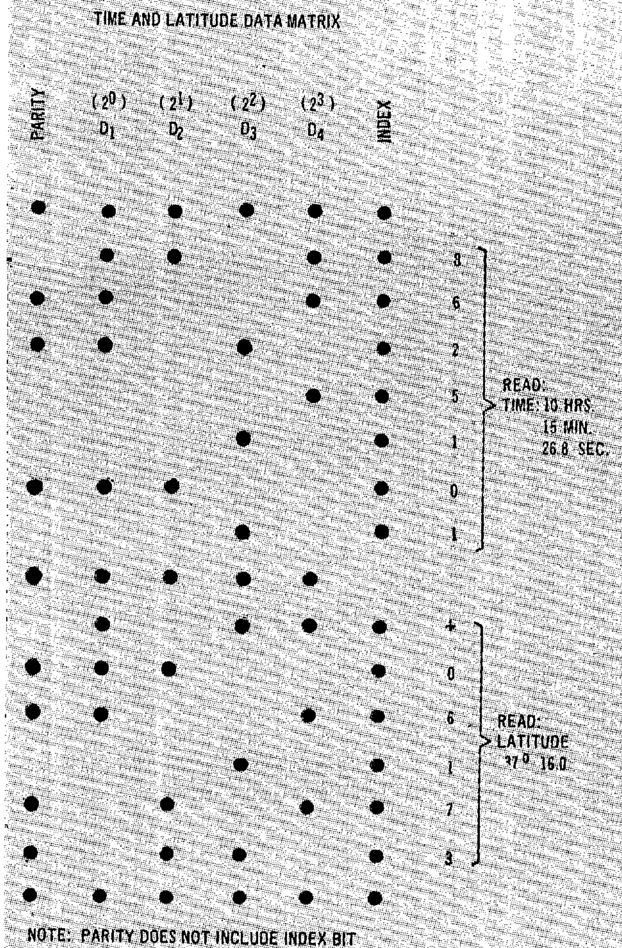
Acknowledgement

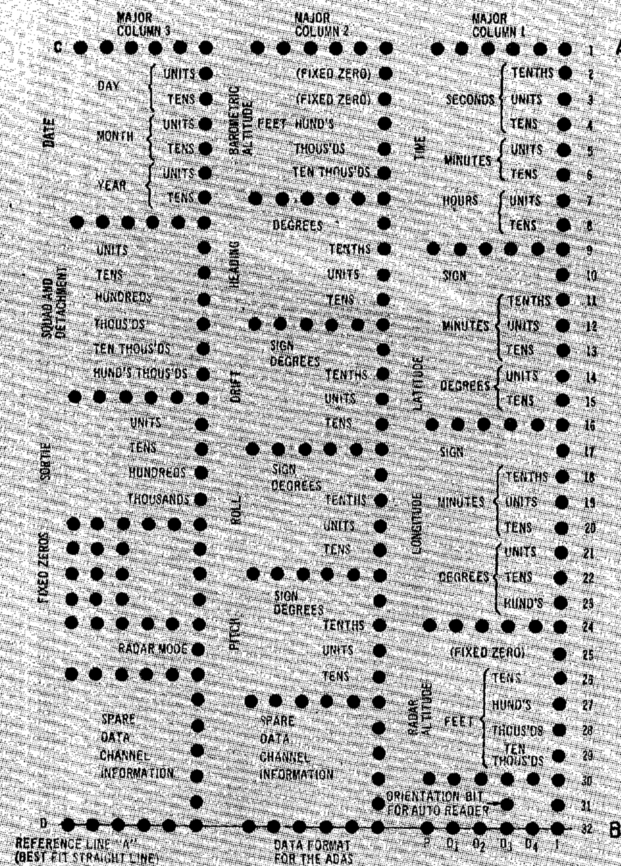
The work upon which this article was based was partially supported by contract AF 33(615)-1938 from the Laser Technology Laboratory at the Wright-Patterson Air Force Base, Ohio, and by the independent research program of Sylvania Electronic Systems, a unit of General Telephone and Electronics Corporation, at Mountain View, Calif.

References

1. D.A. Kleinman and P.P. Kisliuk, "Discrimination Against Unwanted Orders in the Fabry-Perot Resonator," Bell System Technical Journal, vol. 41, Aug. 1962, pp. 453-462.
2. T.R. Koehler, "Mode Structure of a Three-Reflector Cavity," IBM Research Paper RJ-260, Aug. 1963, International Business Machines Corp., San Jose, Calif.
3. S.A. Collins and G.R. White, "Interferometer Mode Selector," Applied Optics, vol. 2, April 1963, p. 448.
4. H. Manger and H. Rothe, "Selection of Axial Modes in Optical Masers," Physics Letters, vol. 7, Dec. 15, 1963, p. 330.
5. H. Kogelnik and C.K.N. Patel, "Mode Suppression and Single Frequency Operation in Gaseous Masers," Proc. IRE, vol. 50, Nov. 1962, p. 2365.
6. S.E. Harris and R. Targ, "F-m Oscillation of the He-Ne Laser," Applied Physics Letters, vol. 5, Nov. 15, 1964, pp. 202-204.
7. S.E. Harris and O.P. McDuff, "F-m Laser Oscillation—Theory," ibid., pp. 205-207.
8. E.O. Ammann, B.J. McMurtry, and M.K. Oshman, "Detailed Experiments on Helium-Neon f-m Lasers," to be published.
9. G.A. Massey, M.K. Oshman, and R. Targ, "Generation of Single-Frequency Light Using the f-m Laser," Applied Physics Letters, vol. 6 Jan. 1, 1965, pp. 10-11.

Reading +3BCD data





Data format for the ADAS. All relevant mission data can be annotated by this high-density marking system.

The auxiliary data annotation set uses an excess-three binary-coded-decimal format (+3 BCD). This format can be read by optical character-recognition systems that enable machines to perform at least part of the analyst's task. This is how +3 BCD format is read:

Arrangement of data in the crt raster is shown above, right. The data format is broken down into three major columns, with each column divided into data blocks bordered by index dots. In major column 1 the index dots appear on lines 1, 9, 16, 24, 30 and 32. They also occupy the entire far right hand column.

With two exceptions, all the variable data—time, latitude, longitude, drift, etc.—appears in major columns 1 and 2. The exceptions are radar mode and part of the spare data channel information. All fixed data—date, squad and detachment, sortie—appears in major column 3.

In each data block, the most significant decimal digit is at the bottom of the block and the reader should start reading at the bottom and work up. If a sign is associated with the data block it is read on the topmost line.

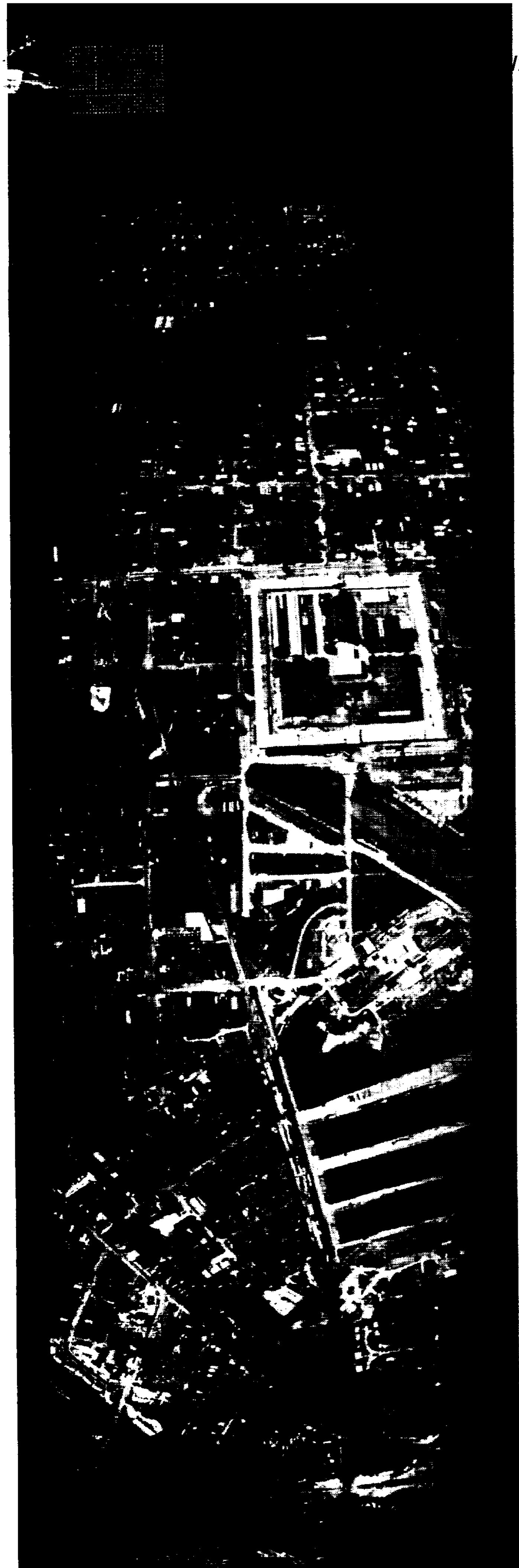
In the figure above, left, is a portion of the data raster consisting of the time and latitude data blocks. These blocks are lines 1 through 16 of major column 1 above. There are six minor columns in each data block, reading from right to left as follows: Index, D_4, D_3, D_2, D_1, and parity. D_4 is the 2^3 bit in the binary code, D_3 is the 2^2 bit, and so on.

The sixth column contains the parity bit. Odd parity is used in the ADAS system; this means that when counting the 2^0, 2^1, 2^2 and 2^3 bits in any line, presence of a parity bit indicates an even number of bits. Conversely, if the number of bits is odd, no parity bit will appear. The index bit is not included in the count to determine parity.

In the table at left the conversion from decimal to +3 BCD is given. By using this with the sample data blocks for time and latitude it can be seen how the ADAS display is converted to decimal data.

CONVERSION FROM DECIMAL TO EXCESS THREE BINARY CODED DECIMAL (+3 BCD)

Decimal	Excess Three Equiv. No.	+3 BCD (Least significant bit at left)			
0	3	1	1	0	0
1	4	0	0	1	0
2	5	1	0	1	0
3	6	0	1	1	0
4	7	1	1	1	0
5	8	0	0	0	1
6	9	1	0	0	1
7	10	0	1	0	1
8	11	1	1	0	1
9	12	0	0	1	1
+		1	0	1	1
−		1	0	0	0
Blank		0	0	0	0



control system that supplies a sequence of intensification pulses to the crt to turn the beam on. These unblanking pulses must be supplied in various widths to assure optimum exposure on different types of sensor films. It is the combination of deflection and unblanking control signals, synchronized, that produces the data raster.

The deflection-control circuits simultaneously generate column, line and section gating pulses, which are combined in a digital-to-analog converter to produce two sets of staircase waveforms. One set is used for the crt horizontal deflection voltage, and the other for vertical deflection. Supplying these two deflection voltages produces the sequential stepping of the electronic beam to every dot location in the data matrix.

Counters move the dot

Data is scanned first by line, by section, and finally by major column. A minor column is a row of vertical dots. Six minor columns make up a major column, and 16 lines, six minor columns wide make up a section. This arrangement is shown on page 108. Column, line and section counters are the framework of the deflection-control circuitry.

Frequency-divider networks and a master oscillator position the dot in the data matrix. The minor column is produced when the output from the master oscillator passes through a divide-by-six network. This network's last flip-flop triggers a line counter and moves the dot one minor column over.

The crystal-controlled clock (master oscillator), which operates at a frequency of 741.1 kilocycles, also drives a divide-by-32 counter that triggers the minor column through a retrace control circuit. This circuit simply counts the number of steps in the deflection voltages so that at the end of a column the time for one step is reserved for circuit (÷32 counter) settling. This gives the crt beam one whole dot period to retrace from the bottom line of the display back to the top. The retrace control circuit also suppresses the trigger to the column counter for one count and simultaneously produces a blanking pulse, which inhibits the display during this time. A trigger from the section counter initiates the retrace action.

For proper ASA settings, dot exposure at the five different reconnaissance camera stations is varied by changing the width of the gating pulse which controls the dot display period. This control of the gating (unblanking) pulse is accomplished in the auxiliary data translation unit by combining, in a diode matrix, outputs from the same chain of flip-flops that make up the initial divide-by-32 counter in the deflection control circuitry.

Seven levels of exposure are available; the highest is achieved by allowing a dot to be displayed

◀ **Aerial reconnaissance photograph shows the ADAS display at upper left. The high data-density format permits recording the maximum amount of reconnaissance information in a minimum area of sensor film.**

Electronic detours of broken nerve paths

Paralysis is often caused by a 'washout' in a neural road from the brain to a muscle. Researchers are testing an alternate route via another muscle and an electronic stimulator

By Luiji Vodovnik and William D. McLeod
Case Institute of Technology, Cleveland

A recent lunch was one of the most dramatic events of Edward Roszak's life. Trailing wires and wearing thick-rimmed glasses attached to electrodes and more wires, he was wheeled over to a table and he began to feed himself. To casual onlookers at Highland View Hospital in Cleveland, it seemed a slow, cumbersome way to eat. But they were unaware that three years before it had seemed unlikely that Roszak would ever use his arms or legs again.

The patient looked down, and his once-useless right arm reached out over the table. He moved his head again, and the arm descended slowly upon a spoon. He shrugged one shoulder, and his fingers grasped the spoon; then his arm moved it, first to the food, then to his mouth.

This meal, repeated several times a week, was a test of an arm-aid developed by Highland View and the Case Institute of Technology. After they analyze Roszak's use of the arm, the researchers expect to develop a device for commercial use.

As with many paralytics, this patient's muscles are undamaged. His trouble is that his nerve circuits are not conducting commands from his brain to certain muscles. Now, aided by an electronic system that bypasses the damaged nerve, this man can use a shoulder muscle to generate electrical signals that cause a hand muscle to contract.

The authors

William McLeod is assistant director of the Cybernetic Systems Group at Case's Engineering Design Center. He received his bachelor's and master's degrees from the University of Toronto.

After spending a year as a research associate with the Cybernetics System group at Case, Luiji Vodovnik returned to his native Yugoslavia as an assistant professor at the University of Ljubljana.

The system, still being developed at the Case Institute of Technology, is believed to be the first to use one muscle to activate another whose neural link with the brain is broken. Although Case's experiments have been limited to restoring motion in an arm, the researchers are confident that their approach will also work on other extremities.[1]

The six arm movements

The patient's glasses are not ordinary spectacles. Their frame holds a small arc lamp that activates photocells in the table top. Over each eyebrow is taped a single-pole double-throw switch.

By moving his head to aim the arc light at the proper photocell, the patient can select a program from the few that have been stored on magnetic tape. These programs control the rotation of the shoulder and of the upper arm, the movement of both toward and away from the body, the bending of the elbow, and the twisting of the wrist. By winking or blinking, he triggers a switch over an eyebrow, thereby overriding the tape to stop a movement before it is completed—for example, when the hand comes down upon an egg, it is advisable to stop its downward movement as soon as contact is made.

For the sixth movement, grasping, the researchers have developed a way to bypass a break in the neural circuit, allowing the hand-clenching muscle to be operated by electrical signals from the patient's shoulder on command from the brain.

In a healthy body, the five gross motions are controlled semiconsciously from a "program" in the brain; conscious control is required only for clenching, which requires feedback to the brain.

For the gross motions the Case system, like other electronic methods of reactivating useless limbs, uses external power—in this case, fluid power from carbon dioxide. But to drive the hand-for almost the full time of a linear column count—39 microseconds. For the lowest exposure level, the dot is displayed for about two microseconds.

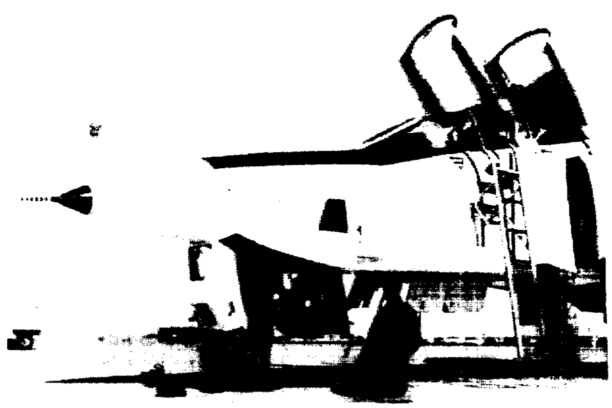
Screw plugs inserted in the fixed-data card select the exposure levels. The pulse that regulates the exposure is passed by an AND gate in the unblanking amplifier to control the data "on" time.

In the recording head assemblies at sensor stations other than photographic reconnaissance cameras, circuitry integrally potted with the crt provides proper spot focus and intensity control. Additional diode circuitry is used for d-c restoration and amplitude clipping of the unblanking pulse. This enables the crt to have a light output pulse whose peak intensity is independent of unblanking pulse lengths.

More needed

The ADAS is only part of the solution to the problem of fast interpretation of reconnaissance and surveillance photographs. Bottlenecks still occur because the photographs and their annotation must be subjected to human analysis. The Air Force, at its Rome Air Development Center and Wright-Patterson Air Force Base, is studying systems that will mechanize and speed up interpretation of military intelligence. One approach combines a central data recorder and ADAS so that once the mission profile data is stored on magnetic tape, it can be computer-processed to generate intelligence information in near real time.

Three-man photo-intelligence team at work inside a reconnaissance data-reduction shelter. The ADAS lightens their work load.



Recording head assemblies and a panoramic-camera reconnaissance system are being mounted in the nose of a supersonic RF-4C reconnaissance aircraft.

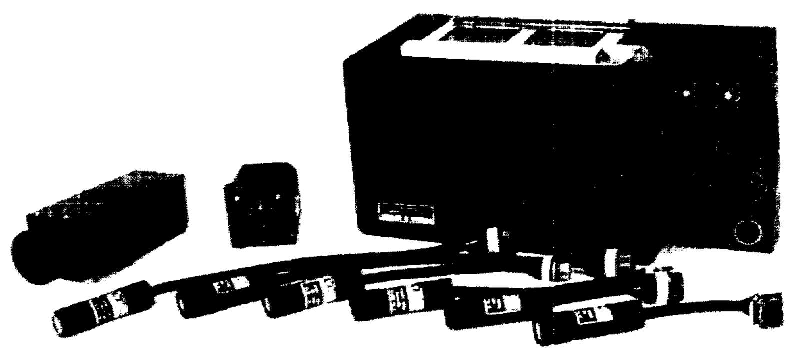
ADAS and data recorders

The armed services are making extensive use of the automatic data annotation system, ADAS, to identify reconnaissance film but they still have to use optical techniques for information readout. Recently, the Rome Air Development Center awarded the first of several contracts for central data recorders and other automatic film-processing equipment. Bids are now being submitted on a contract for similar equipment for the Aeronautical Systems division at Wright-Patterson Air Force Base.

The central data recorders will be used with real-time computers. An airborne ADAS would feed mission-profile data to the recorder; the information would be buffered, processed, and stored on recording tape. After the plane landed, the recorder's memory bank would feed the profile information to a computer. The computer could then drive a chart or map to plot the course the plane had followed.

Since all the target's coordinates would be stored in the computer's memory, intelligence officers who interpret photos could almost instantly spot a target of interest. By proper interrogation of the computer, they could constantly update or compare target data.

The Army is also investigating methods of automatically interpreting surveillance photos. According to one Army spokesman, the most urgent requirement in the surveillance program is an automated imagery interpretation system that can pick out targets such as tanks, guns, launchers, supply dumps, and so forth without human intervention. Additionally, they want the automatic system to be able to review specific areas to pick out frames in which changes have occurred. W.J.E.



Compact assemblies make up the auxiliary data annotation set (ADAS). The special recording head assemblies are in the foreground; behind them (left to right), is the cockpit test display unit, time insertion unit, and the auxiliary data translator unit.